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Production Manual for the Great Lakes Region

Stabilized Moulded Earth Blocks - SMEB

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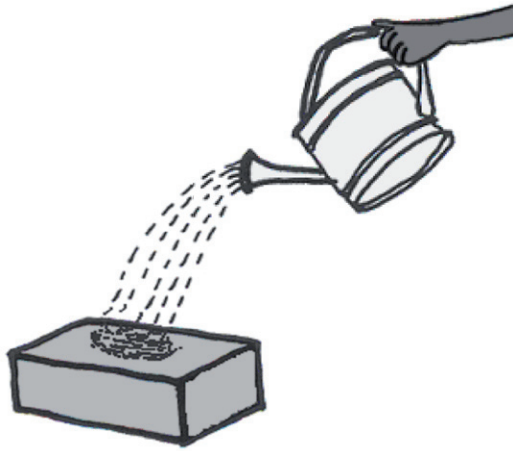
4.4. Simplified erosion test

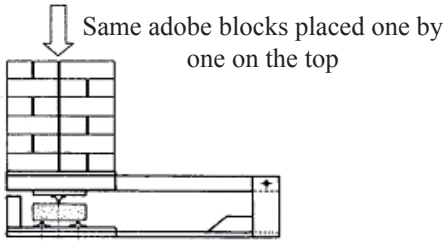
It is also interesting to perform this test by reproducing soaking / drying cycles. These are the successive cycles, to which are naturally exposed buildings (and therefore blocks), which tend to further accentuate even more the damage.

It is definitely in contact with water that stabilized block shows a better behavior than traditional adobes : to test whether the choice of the soil was correct and the production cycle well done, with a long wet cure, brick should hold up well. Otherwise, it means that the steps are not properly implemented and must be reviewed.

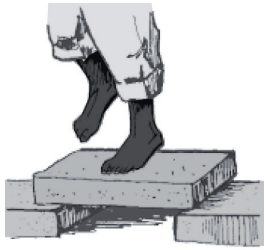


4.3. Simplified strenght test

To control the quality of adobes, choose three random blocks and test them one month after production with the brick-breaker. If they resist to 30 blocks without breaking, quality is satisfactory.



Or simply take a block, put it in balance on supports and go stand on it, if the block can withstand the weight of a man (70 kg), the quality is satisfactory for small structures.



Ultimately, everything depends of the desired strength and the intended use of the adobes.
The one-month period to observe before testing the mechanical strength (period after which the block is the strongest) therefore requires to program the production of stabilized adobe sufficiently in advance of their implementation on site.

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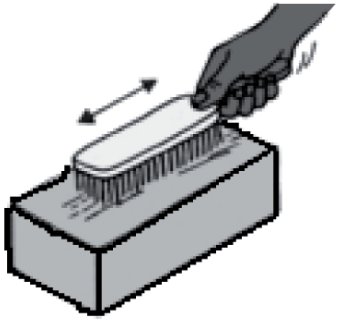
4.2. Simplified abrasion test

Check the behavior of stabilized adobes in a wet environment :
at the end of the wet cure (28 days), immerse in water a selection of stabilized adobes until water saturation (at least 24 hours). In this state of saturation, verify the product qualities (abrasion, strength, erosion).

The first difference between the stabilized brick and the traditional brick is its better resistance to water. The mechanical strength of a stabilized adobe is not necessarily superior to traditional adobe, especially if it is a very clayey adobe with added fibers (often very resistant block).

Test made using a wire brush.

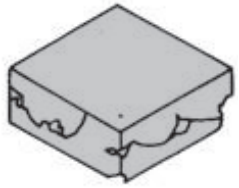


The one-month period to observe before testing the mechanical strength (period after which the block is the strongest) therefore requires to program the production of stabilized adobe sufficiently in advance of their implementation on site.

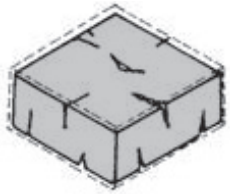
4.1. Shape control

General appearance

No vacuum is accepted at the edges and empty gaps on the side faces are unacceptable : in this case, block need a better filling and compression of the earth along the edges and corners during molding.

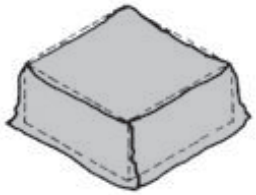


After drying, cracks superior than 5 cm can't be accepted (if so, the soil is too clayey, sand or rather fibers should be added to it).

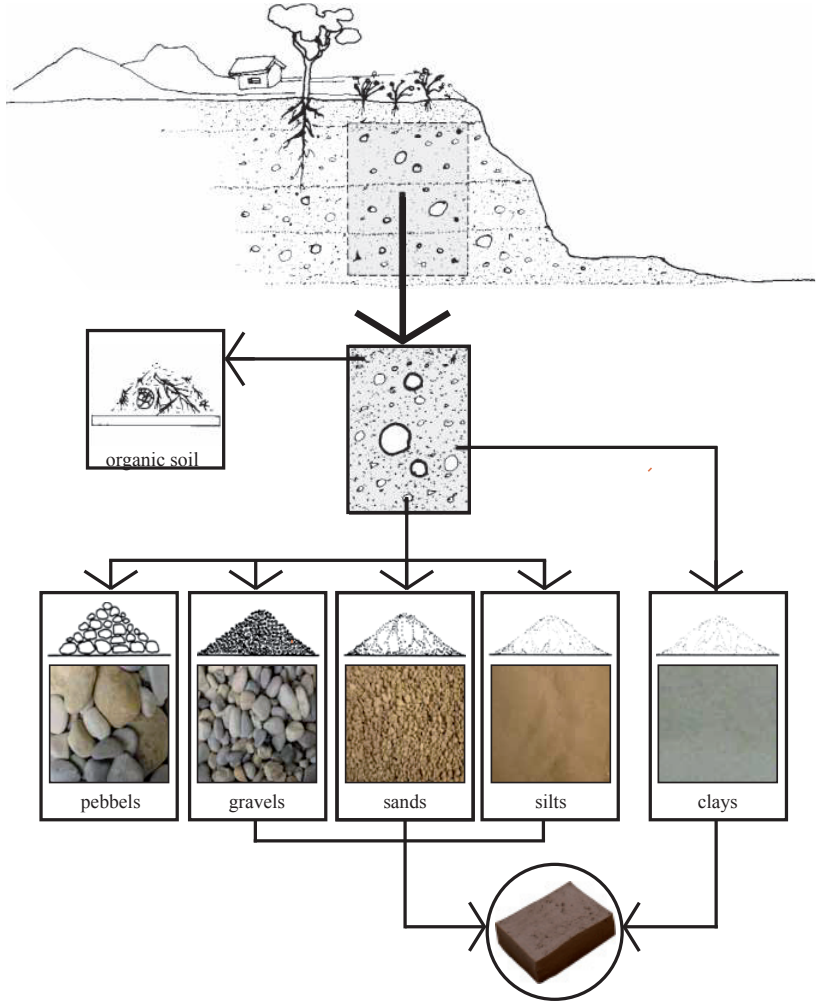


Schrinkage (dimensions)

The base should not increase by more than 5%.



1.1. Soil constituents



A good stabilized adobe soil should consist of a sandy soil (larger quantity of sand as silt, clay, or potantial small gravels). The part of clay must be small : clay action is contrary to the action of ciment to introduce. Using organic soil should be avoided (proportion by weight !).

1.2. Soil selection / identification

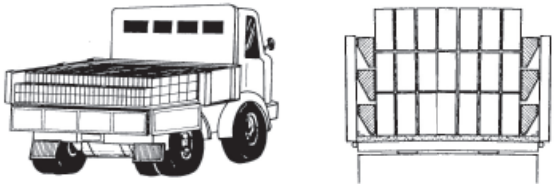
With a solid experience, it is not necessary to practice laboratory tests. Field trials are then often more than enough to understand the behavior and the specific characteristics of soils, so long as diagnostics marks agree. If discrepancies are noticed, further laboratory tests will be mandatory.
In this way it is possible to :
• know how to choose a soil in function of its intended use,
• or, conversely, know how to use optimally soil according to its characteristics.

The soil sample must be representative of the soil that has to be analyzed.
In order to do this, it is necessary :
• to extract very localized samples, that will not be corrected (add or remove elements from it)
• to multiply the samples when the soil is heterogeneous, rather than trying to make an average (which may never be exact).

It is always useful to refer to local knowledge. Information can be gathered by interviewing former masons and elders. It is important to be able to interpret this collected information, particularly through observation of existing buildings.

Transport

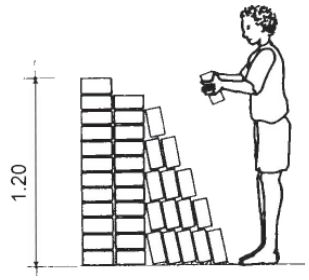
In order to minimise the damage of Moulded Earth Blocks during transportation :
• spread a layer of sand under the blocks,
• use small wooden wedges to align the adobes against the sides of the truck.
Bricks are stronger if they are transported on the slice.



An other choice can be made : to carry the extracted soil and water on the site and produce adobes directly on the construction site to reduce the risk of loss in transit.

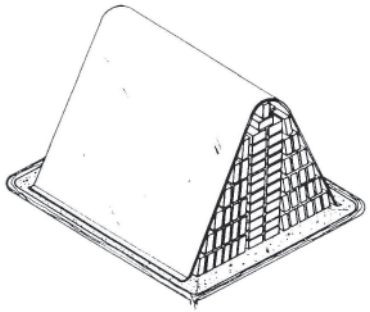
Storage

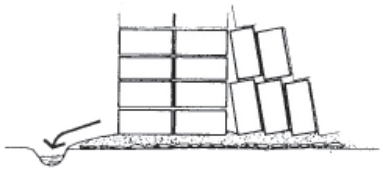
Once the wet curing is totaly finished, if the storage is meant to last in time before use of the blocks, it is possible to further densify the stock by overlaying stabilized bricks.



Maximum height

Although stabilized bricks withstand much better to water than conventional bricks, it is advisable to cover them with plastic sheet. In this way they remain in a moist atmosphere increasing their performance.
In this case, care should be taken to place the adobes on a protective insulating layer against capillary rise, and also to dig peripheral ditches to keep away runoff water.





Protective layer of sand with
a drain along the periphery.

Tests

Beware : if a sandy soil has little cohesion, and therefore little dry strength, it has the advantage not to crack (minimum withdrawal).
On the other hand, clayey soil has a high cohesion, and therefore high dry strength, but it may crack significantly.

Proper soil for producing stabilized adobe is rather a sandy soil, which naturally presents little clay : it does not stick.
In its composition, it is similar to the soil used for interior plasterwork or stabilized compressed earth blocks production (SCEB).
Its lack of natural resistance will be improved by adding cement a small proportion of ciment. The amount of clay should be very small not to cause cracks, but a small amount is necessary to link to the earth before the action of the cement, which requires time.

- Smell test :

This test consists in smelling wet soil. Smell a moistened quantity of soil. If it has a musty odor, similar of that of wet agricultural soil, it is organic and should be rejected. As the humidification increases, the smell will be more intense.
Recall that the section of organic soil is unsuitable for construction.

- Preliminary analysis of the texture :

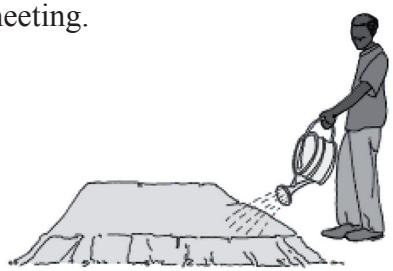
Visual examination :
It initially helps to get an idea of the relationship between large elements, but also of the sandy fraction and the fine fraction (limit of visibility to the naked eye) ; the dominant fraction determines the fundamental properties of the material.

Wet curing

Wet curing is essential for any material containing a part of cement, it has to be done as soon the blocks don't deform anymore by touch.

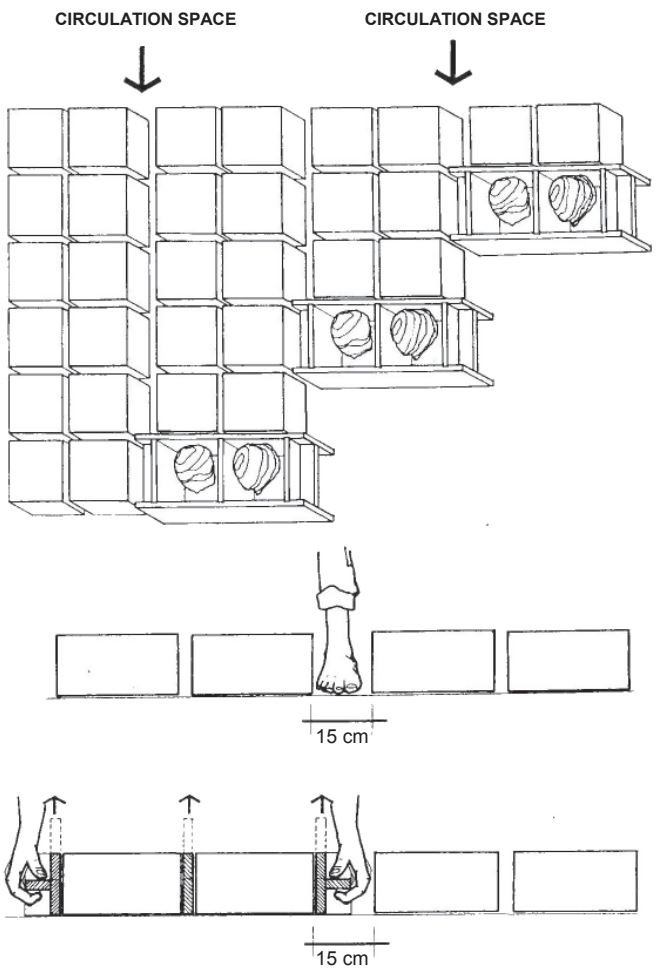
Wet curing slows the cement setting by avoiding water evaporation, to improve its mechanical strength. It is recommended to observe a minimum of 7 days (possibly 10 or more) of wet cure.
For this, and depending on the availabilities, several options are possible :

- maintain a humid environment around the adobe blocks by covering them up with 4 cm of sand, immediately moistened and then moistened every morning and evening during a week,
- another option is to cover with plastic sheeting.



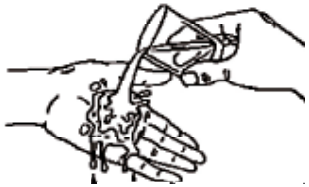
Provide for a circulation passage after every metre to allow for movement to cover the stabilized adobes for the wet curing.

Respect the alignments to better organise the space for efficiency.



Touch test* :
- Rough and without cohesion : sandy soil.
- Silky appearance, and once wet moderately plastic : silty soil.
- Presence of resistant and plastic clods, and once wet sticky and malleable : clayey soil.

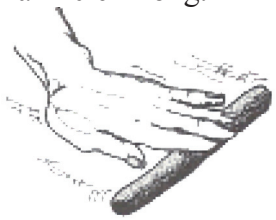
Hand washing test* :
- Easily rinsed off : sandy soil.
- Rest of powder on the skin : silty soil.
- Soapy and difficult to rinse off : clayey soil.



** Tests done with the finest particles of the soil only (particles ≤ 2 mm) : from the sands to the clays.*

- Cohesion Test (cigar test)* :

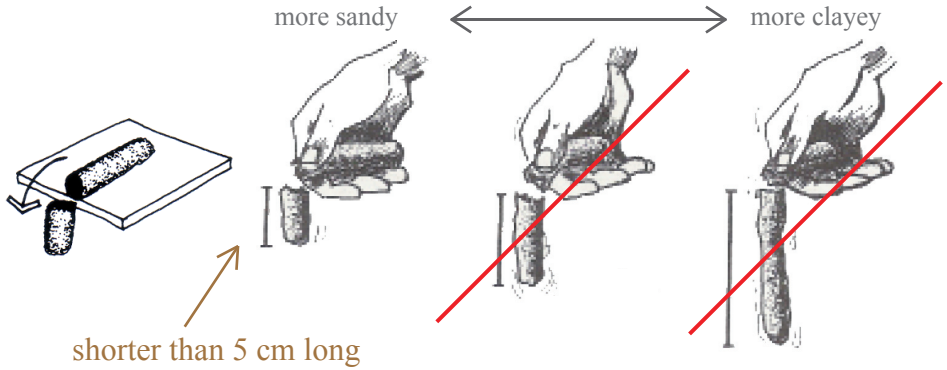
Roll a cigar (not sticky) of 3 cm in diameter (with particles less than 5 mm diameter) and more than 20 cm long.



Then drag it into the vacuum from a flat surface. This test evaluates the clay content in function of the length of the detached portion:

- Short (less than 5 cm) : sandy soil (low soil cohesion).
- Very long (more than 15 cm) : clayey soil (good soil cohesion but significant risk of cracking).

Repeat the test 3 times in order to derive an average.



In theory to produce a stabilized adobe, during the soil identification tests, the cigar has to breack below 7 cm.

If the cigar would break beyond 5 cm, the soil would be too clayey. If it is not possible to form the cigar (not enough cohesion), the earth will not be used : the brick unmoulding will not be possible.

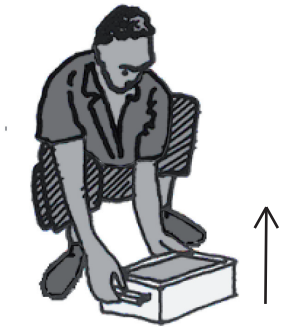
** Tests done with the finest particles of the soil only (particles ≤ 2 mm) : from the sands to the clays.*

Molding / Unmolding

The molding is done on the beforehand prepared production area for this purpose.

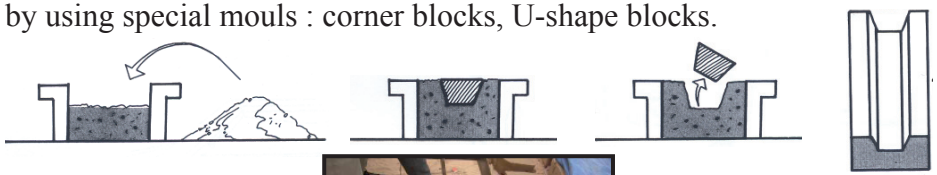
Before moulding, it is important to control the optimal water content ; the molding and the block quality depend on it. If the mixture is too dry, the block breaks, if the mixture is too wet, the block deforms.

During the mold filling, firmly tamp down the angles : the angles of a block are always the weakest parts.

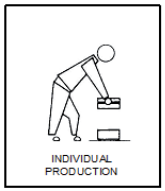


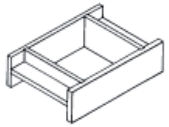
Unmold vertically in order not to deform the brick.

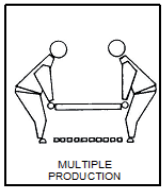
The same recommendations are valid for the production of special blocks, by using special mouls : corner blocks, U-shape blocks.

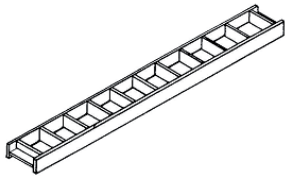


Multiple molds exist and allow the production of several bricks at the same time. However, beyond two bricks at the same time, large molds often require two people to be handled ; the production site has to be large enought and flat to accept multiple ladders.

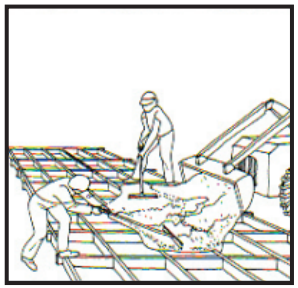


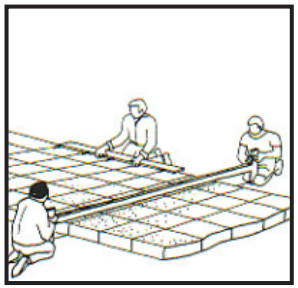


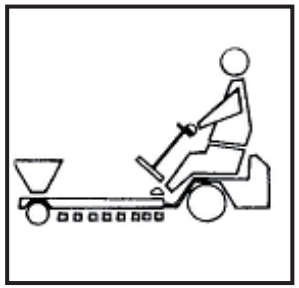




More mechanized systems or automated systems exist in certain contexts.

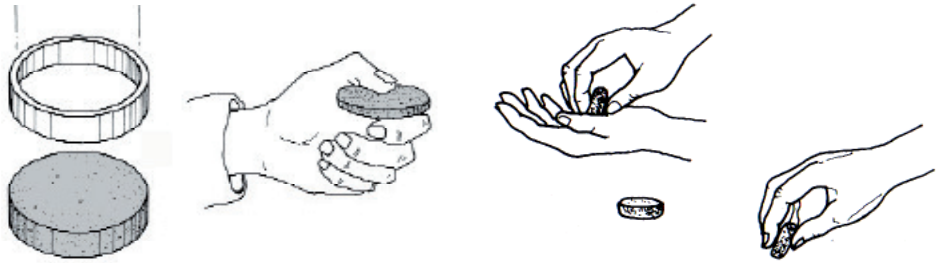






- Dry strength test* :

Form a pellet using a ring (from a PVC tube for example).
From made pellets (with the portion of fine particles < 2 mm diameter) that are completely dry : try to crush and pulverize it between the index finger and thumb.

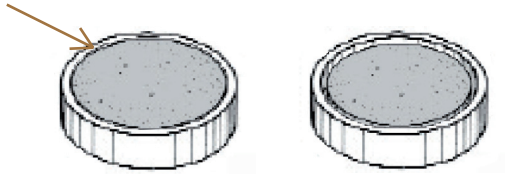


- The pellet breaks easily and reduces itself into powder without difficulty : silt or fine sand, little dry strength.
- The pellet breaks and finally, after some efforts but without too much difficulty, reduces itself into powder : silty clay or sandy clay, average dry strength.
- The pellet is very difficult to break and it is impossible to reduce it into powder : a lot of clay or almost pure clay, high dry strength, but significant risk of cracking.

** Tests done with the finest particles of the soil only (particles ≤ 2 mm) : from the sands to the clays.*

- Shrinkage test (sun-dried pellet)* :

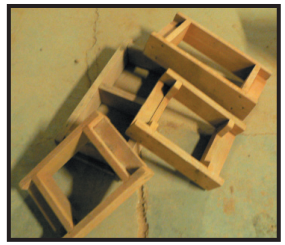
• No shrinkage and cracking : sandy soil.
• Little shrinkage and cracking : low clay soil.
• Important shrinkage and cracking : clayey soil.



** Tests done with the finest particles of the soil only (particles ≤ 2 mm) : from the sands to the clays.*

Mould and mould preparation

Mould shape differs according to the size and the type of brick to be produced.
The materials used are usually metal or wood.

special molds must be made to produce the individual blocks: corner block, U-shape block, ...


Before use a wooden mould, soak it in water untill it is fully saturated, in order to the mould do not absorb water from the soil mixture to molding and make it difficult to unmold. Thus it is regularly rewetted between two bricks.

To facilitate the unmolding, it is possible to brush the mould with oil (used car oil for example, but leaves traces on the bricks, so be careful if the brick wall do not have to be plastered). Or sprinkle the mold with sand works well to drag the brick.

Optimal water content (ball test)

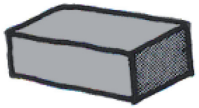
The optimum water content is reached when it is possible to mold and unmold easily the brick without collapsing.
For this, it is possible to perform a small test by vibrating a ball of wet mixture on the palm of his hand.

- if the ball does not deform, the mixture is too dry
- if the ball collapses completely, there is too water in the mixture
- if the ball is deformed without totally collapsing, the water content is correct.

too dry →

too wet →

suitable →

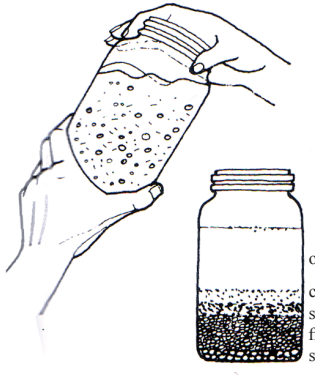


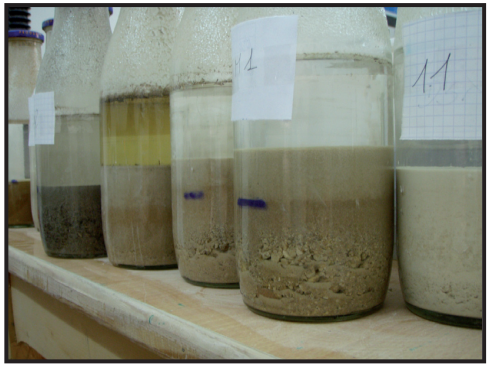
- Sedimentation Test* :

The advantage again is to analyze the percentage of fines present in the earth by comparing superimposed layers of different grains and to check that no expansive clay are in the soil (expansive clay can induce heavy damage and destruction of buildings).

Protocol :

- In glass transparent jars or bottles : have ¼ of the volume of soil (note pitch) and ¾ of clean water,
- let stand for a bit, then shake and decant for 1 h. Shake again and decant during 8 hours,
- measure the total height of sedimentation and observe whether there has been a swelling of soil volume (swelling land) or not,
- then measure the height of each layer to assess the proportion of different grains : sands, silts and clays. If the soil selection is good to produce adobe (the best test to perform is still to produce a brick and control her quality before launching a large-scale production), these measures can constitute a reference throughout production. For that it is important to conserve this « reference bottle ».





** Tests done with the finest particles of the soil only (particles ≤ 2 mm) : from the sands to the clays.*

more sandy ⟷ more clayey

Before launching a large-scale production, the best test to perform is still to produce a brick (or more with mixtures of different earth with different proportions of cement) and let it dry to do a quality test and evaluate its behavior. This minimizes the risk of mistake in the choice of raw material and therefore :

• the loss of blocks in case of too clayey soil,
• the poor quality of the items.

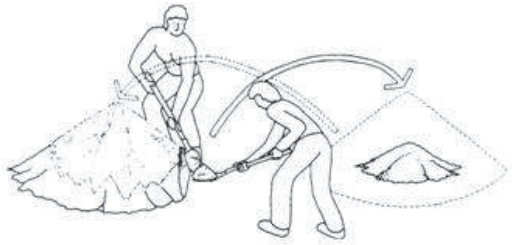
Tests done with the finest particles of the soil only (particles ≤ 2 mm) : from the sands to the clays.

Wet mixing

Add water with a watering can and mix till obtaining a plastic state (to obtain a soft dough).

When moistening the mixture to implement, it is important to proceed by using small quantities. Only wet a part of the mixture and leave the rest dry : once the mixture contains wet cement, it is to be used within 30 minutes after watering !

Mix together the dry soil and cement, in order to homogenize the whole. In general, and for all mixture comprising cement; mix well in dry state the cement and the aggregates (in this case the soil). To do this, it is necessary to move 3 times the whole pile to be sure everything is well homogenized.



1.3. Soil stabilization

The lack of natural cohesion of the soil is compensated by the action of cement.
This action is not possible if the raw material is not inert enough (no cracking). If there are cracks, cement can not build its roots network through grains in earth. In this case, the cement action is canceled and produced bricks present a very poor quality : blocks production is lost.
If the soil is too clayey (cracking) may be added to sand to make it inert and no longer crack.

The cement stabilization does not prevent having to select a suitable earth :
• a good soil (sandy) even weakly stabilized can give high performance blocks,
• an unfit soil even if strongly stabilized will give poor blocks.
Generally, a small amount of cement is enough to obtain good results, meaning a dosage between 7 and 10% of stabilizer (mean 1 volume of cement for 10 volumes of sandy soil).

The cement used for production must not have been exposed to humidity before use (due to storage conditions, transportation, etc..). The water must be clean and not contain suspended matter. No bag containing hard lumps is accepted.

2.1. Definition / main characteristics

The stabilized adobe or SMEB is a molded, naturally dried (unbaked) mud brick, which contains a small proportion of cement, in order to improve its behavior, in particular its resistance to water.

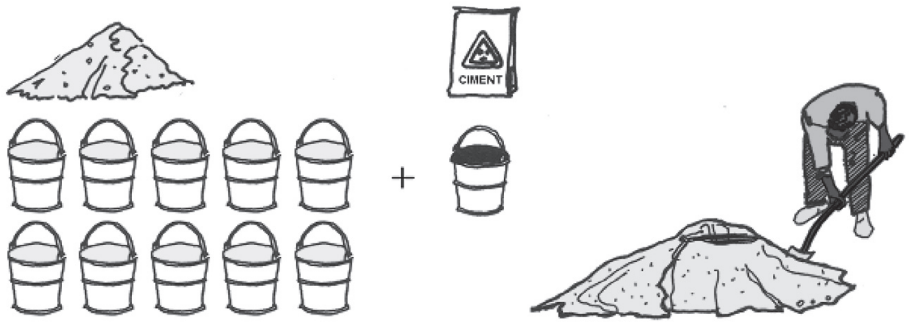
Stabilized adobes are more water resistant than normal adobes, but they are more expensive, due to the addition of cement.
Their use may nevertheless be appropriate if it's reduced to the most exposed places :

- to strengthen parts of the building which has to withstand extreme loads and stresses, such as :
  - parts in contact with the ground (in contact with water infiltration and capillary rise),
  - base of wall (cycle of wetting and drying, mechanical erosion)
  - foundation slab (capillarity)
  - window sills,
  - wall corners (mechanical erosion, impacts)
  - opening frames (tensile cycles, mechanical erosion)
  - the parapet, etc
- or when the available soil doesn't possess the adequate characteritics to make classic quality adobes (not enough binder naturally occuring in the soil).

Dosing and dry mixing

Prepare the mixture on a clean surface and as close as possible to the place of use.
After sieving, to avoid that fine particles are separated from large grains by remaining in the center of the pile; mix the dry sieved soil.

Add the stabilizer (cement) to the dry soil, the dosing may be variable according to the soil's nature and its desired characteristics. In order to really enhance the strength of the adobe block, it is preferable that the cement dosing is at least equal to 7%.
To stabilize between 7 and 10%, it is often done as follows : 1 part cement for 10 parts of soil (a stabilization ≈ 9%).
However, tests should be performed in advance to define the correct dosing depending on the sought characteristics and quality of the blocks.
To be sure, it is important to perform several « tests bricks » with different dosages and to conduct quality control after production, in order to choose the best one.



Sieving

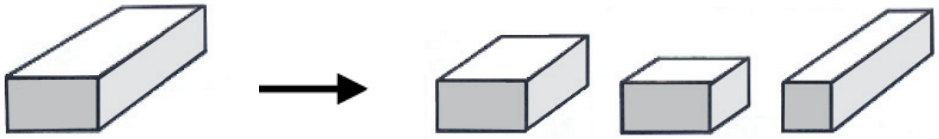
If the used soil presents grains with a too large diameter that are incompatible with the size of the molds (and elements to produce), it is necessary to sieve the soil (usually 1.5 cm).

2.2. Block types

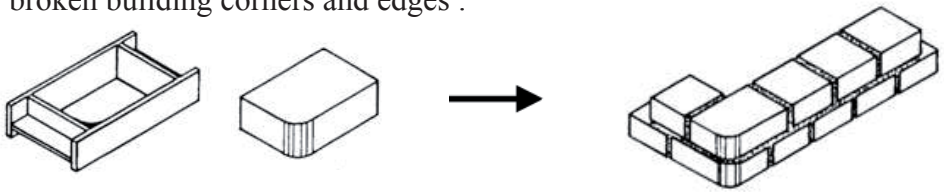
Adobes are blocks, masonry elements whose shape is square or rectangular depending on location (local culture), soils and usages.
A too elongated brick (length ≥ 2 times the width) is more likely to suffer withdrawal therefore susceptible to cracking, while a more square-shaped brick more stable is.

Often the bricks are cut on site to allow good cross joints.

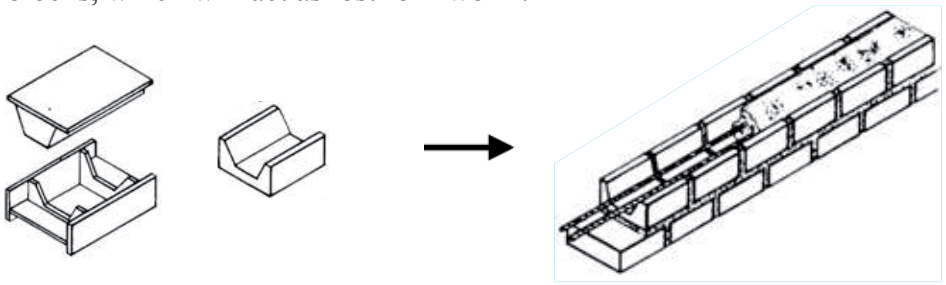
But in case of major construction program, and especially for stabilized blocks, it may be wise to produce blocks whose dimensions are adapted to the size of the building walls and derived from a first basic block (1/2 blocks, 2/3 or 3/4 blocks, etc.), in order to prevent to cut whole moulded earth blocks on site and so to avoid losses (broken blocks) and save time with to facilitating the block work on site.



It is also possible to foresee the production of special blocks : U-shape blocks, rounded blocks, etc...
To realize the wall angles, doorway and window frames, pillars, etc.., which are subject to higher mechanical erosion than other parts of the wall, the anticipated use of rounded blocks can avoid ending up with broken building corners and edges :



The implementation of certain parts of the building, such as ring beams, can be facilitated by using U-shape blocks, or hollowed moulded earth blocks, which will act as lost formwork :

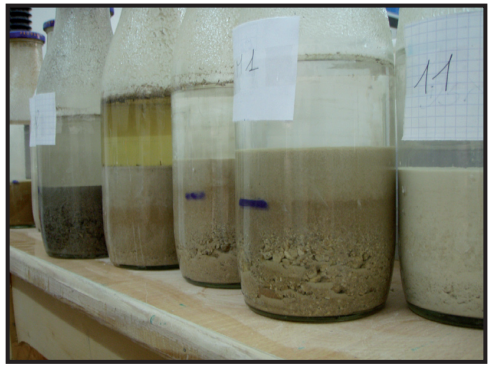


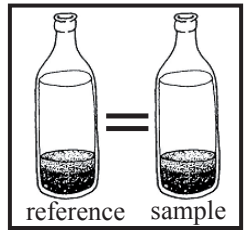
Once sized, the production of these special blocks follows the same production steps as for moulded earth blocks described above, only the molds will be different.

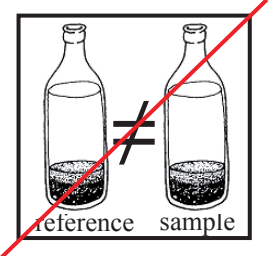
Control of the homogeneity of the raw material

It is important to always check that the extracted earth to produce blocks remains homogeneous throughout the production. Digging deeper or two meters further than the first extraction point, the quality of soil can significantly change.

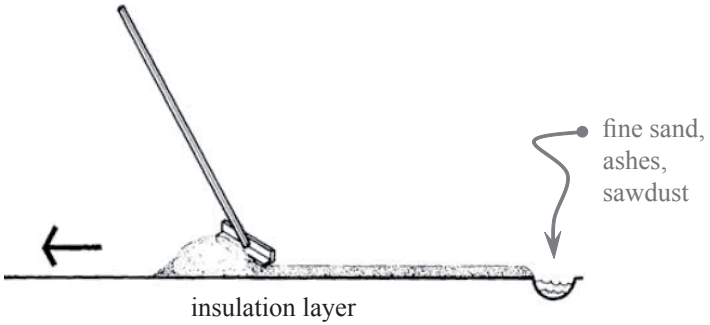
For that, and for not having to redo every time all the tests to determine the quality of soil, it is possible to reuse the bottle containing the sedimentation test with the selected earth : previously analyzed and considered suitable for its use.
This first bottle serves as a « reference bottle » to compare with the new soils extracted, by making identical bottles regularly carried out from quarry during successive samples. If the the separation of the different layers remains similar, we can deduce that the quality of new extracted soil has not changed and remains suitable to produce adobes.
However, if the 2 bottles do not represent the same characteristics, all the various tests must be repeated to ensure that the new soil is suitable.





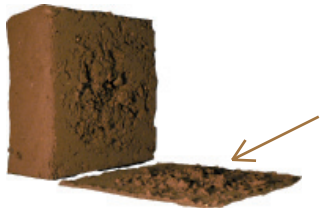


An insulating layer is spread on the entire surface (sand, ashes, sawdust, etc.) so that the moulded blocks do not adhere to the ground :



If the surface isn't well prepared upstream, the risk is :

• to obtain blocks of poor quality with a missing part, in case the block remains glued to the ground,



• having to resize the blocks, if instead a part of the soil stays sticked to the block (generating extra-working time and manpower and thereby extra-costs).

3.1. Production organisation

Space

The first thing to ask is where produce ? Two alternatives are possibles :

• on the construction site by transporting earth from the quarry and cement and water,

• or directly to the quarry, with water potentially available nearby (often in ancient flooded lowlands) and dy transporting cement only. But that means :

- to ensure the safe storage of cement at the quarry, while a guard is often necessary to keep tools and materials on the construction site
- to transport bricks to the construction site with a risk of breaking bricks to be taken into account.

Then, to produce blocks, the site must be relatively flat and not sloping. The production area is determined by :

• the amount and size of blocks to produce,

• the daily productivity,

• the drying time (with a necessary wet curing time to produce stabilized adobes).

Indeed, the produced blocks remain on site till they are dried. This requires a large production area.

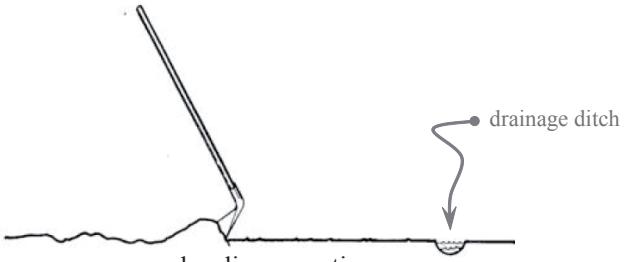
Time

Since moulded earth blocks production requires large amounts of water, it is important to program according to the seasons. That means at the end of the rainy season to take advantage of lowlands full of rainwater.

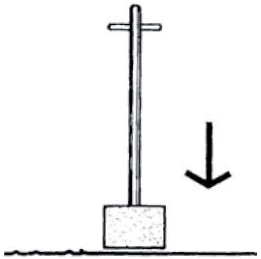
3.2. Production line

Production site preparation

The soil is leveled and compacted to provide a flat surface in order to prevent irregularities :



leveling operation



compaction

If necessary, drainage ditches can be dug all around the site in order to redirect and remove any runoff water.